INDOOR AIR QUALITY ASSESSMENT

Joshua Eaton Elementary School
365 Summer Avenue
Reading, MA 01867

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Center for Environmental Health
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Background/Introduction

At the request of a Jane Fiore, Health Agent, Reading Board of Health, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH), Bureau of Environmental Health Assessment (BEHA), provided assistance and consultation regarding indoor air quality concerns at the Joshua Eaton Elementary School (JEES), 365 Summer Avenue, Reading, Massachusetts. The request was prompted by concerns over poor indoor air quality (IAQ) and the possible connection between IAQ and cancer diagnoses among building occupants. On April 13, 2004, a visit to conduct an indoor air quality assessment was made to the JEES by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. During the assessment, Cathy Gallagher, Risk Communicator in BEHA's Community Assessment Program (CAP), and Ms. Fiore accompanied Mr. Holmes.

The JEES is a one-story, red brick building constructed in 1948. A wing was added and the building was renovated in the mid 1990s. These renovations reportedly included upgrades to mechanical ventilation equipment, windows, boiler plant and interior cosmetics (e.g., walls and floors). The school consists of general classrooms, gymnasium, kitchen/cafeteria, library, computer room, art room and office space. Windows are openable throughout the building.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The school houses approximately 500 kindergarten through eighth grade students and approximately 70 staff members. The tests were taken during normal operations at the school. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in six of thirty-five areas, indicating adequate ventilation in most areas surveyed. Fresh air in each classroom is mechanically supplied by a unit ventilator (univent) system (Picture 1). A univent draws air from outdoors through a fresh air intake located on an exterior wall of the building and returns air through an air intake located at the base of the unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located on the top of the unit (Figure 1). Over the winter, several univent air intakes on the exterior of the building were reportedly sealed with plastic to prevent freezing of heating coils (Picture 2). School officials reported that they were working with a heating, ventilation and air conditioning (HVAC) engineering firm to resolve these issues. Obstructions to airflow, such as items on top of univents and tables and desks in front of univent returns were also observed in a number of classrooms (Picture 3). To function as designed, univents must remain free of obstructions and allowed to operate.

Exhaust ventilation in the 1948 portion of the building is provided by exhaust vents located in ungrated floor level "cubby" holes. These vents were observed to be used for storage in several areas, thereby obstructing airflow (Picture 4) at the time of the assessment. As with univents, exhaust vents must remain free of obstructions to function as designed. Exhaust ventilation in classrooms of the 1990s portion of the building consists of ceiling or wall-mounted vents connected to rooftop motors via ductwork (Pictures 5 and 6). Without adequate exhaust ventilation, excess heat and environmental pollutants can build up and lead to indoor air complaints.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced subsequent to installation to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix A.

Temperature measurements ranged from 69^{o} F to 78^{o} F, which were very close to the BEHA recommended comfort range the day of the assessment. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. It is also difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents and exhaust vents obstructed).

The relative humidity measured in the building ranged from 30 to 43 percent, which was below the BEHA recommended comfort range in some areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Plants were observed in several classrooms. Plants, soil and drip pans can serve as sources of mold growth. Plants should be properly maintained, over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should also be located away from ventilation sources to prevent aerosolization of dirt, pollen or mold (Picture 7).

A number of areas had water-stained ceiling tiles, which can indicate leaks from the roof or plumbing system (Picture 8). Water-damaged porous building materials can provide a source for mold and should be replaced after a water leak is discovered and repaired. Spaces between the sink countertop and backsplash were also noted in several areas (Table 1/Picture 9). Improper drainage or sink overflow can lead to water penetration into countertop wood, the cabinet interior and areas behind cabinets. If these materials become wet repeatedly they can provide a medium for mold growth. Faucet leaks were reported/observed in classrooms 13 and 17.

The building is equipped with gutters and downspouts to direct rainwater away from the building. Several downspouts and gutters were disconnected, leading to water pooling against the building. Excessive exposure of exterior brickwork to water can result in damage over time. During winter weather, the freezing and thawing of moisture in bricks can accelerate the deterioration of brickwork. Damaged brickwork can result in water intrusion to the building interior.

Rubber gaskets around windows in classroom 16 were failing, indicating that the water seal is no longer intact (Picture 10). Replacement of gaskets/caulking and repairs of window leaks are necessary to prevent drafts, water penetration and subsequent damage to building materials, which can lead to mold growth.

Other Concerns

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address airborne pollutants and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter. As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detectable (ND) (Table 1). Carbon monoxide levels measured in the school were also ND.

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, the US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standards requires outdoor air particle levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 8μg/m^3 at the time of the assessment. PM2.5 levels measured indoors ranged from 2 to 29 μg/m^3. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While TVOC levels were ND, materials containing VOCs were present in the school. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may also contain

VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Cleaning products and other chemicals were found in floor level cabinets and on counter tops in several classrooms (Picture 11). Cleaning products consisting of VOC-containing chemicals (e.g., bleach or ammonia-related compounds) can be irritating to the eyes, nose and throat. These items should be stored properly and out of the reach of students.

In an effort to reduce noise from sliding chairs, tennis balls were sliced open and placed on chair legs (Picture 12). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Several other conditions that can affect indoor air quality were noted during the assessment. Accumulated dust was observed on classroom exhaust vents (Picture 2). Exhaust vents should be cleaned periodically to prevent aerosolization of accumulated dust. Accumulated chalk dust was noted in some classrooms (Table 1). Chalk dust is a fine particulate that can easily become aerosolized, irritating eyes and the respiratory system.

Also of note was the amount of materials stored inside some classrooms. Items were observed on windowsills, tabletops, counters, bookcases and in some cases, stored in restrooms. The large number of items stored provides a source for dusts to accumulate and make it difficult for custodial staff to clean. As previously mentioned, dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Finally, an air purifier was seen in one classroom. These units are equipped with filters that should be cleaned/changed as per the manufacturer's instructions. Without cleaning/changing filters, the activation of these units can re-aerosolize dirt, dust and particulate, which can be irritating to certain individuals. The red light of one unit was on (Picture 13), indicating that the pre-filter was in need of cleaning.

Health Concerns

In February 2004, Ms. Fiore contacted the CEH's Community Assessment Program (CAP), regarding a suspected increase in breast cancer incidence among staff at the Joshua Eaton Elementary School. At the time of the telephone conversation with Ms. Fiore, specific diagnosis information on each staff person diagnosed with cancer was not available. Ms. Fiore informed CAP staff about renovations on the Joshua Eaton School that were completed between four and six years ago but at that time was not aware of any current indoor air quality concerns at the school. General information about breast cancer was provided, and a "Risk Factor Summary" on this cancer type developed by the CAP was faxed to Ms. Fiore. CAP staff instructed Ms. Fiore to contact the CAP with additional questions and to refer staff at the Joshua Eaton School to the CEH.

Following the conversation with CAP staff, Ms. Fiore contacted staff in the Emergency Response/Indoor Air Quality Program (ER/IAQ) to request an indoor air quality investigation of the Joshua Eaton School. Information provided to ER/IAQ staff from Ms. Fiore indicated that the request for an indoor air quality evaluation was prompted by diagnoses of cancer among staff at the school. Following the initial telephone conversation with Ms. Fiore, ER/IAQ staff contacted Lisa Cormier, principal of the Joshua Eaton School. In order to further investigate concerns at the school, ER/IAQ staff asked Ms. Cormier to submit a written request to the CEH that contained information on each individual diagnosed with cancer including primary site of cancer, approximate age and date of diagnosis, and approximate dates of employment at the Joshua Eaton School. This request for written documentation is consistent with the CEH protocol for conducting environmental health assessments.

On April 6, 2004 the CEH received a written request from the principal of the Joshua Eaton School that contained a list of four current employees of the school who had reported a diagnosis of breast cancer and one employee with a pre-cancerous breast disease. Name, gender, primary site of cancer, age at diagnosis, approximate date of diagnosis, and approximate dates of employment at the school were reported for each individual. During an April 13, 2004 inspection of the Joshua Eaton School by the CEH ER/IAQ Program, the principal supplied information for two additional former staff members of the school who had been diagnosed with cancer (including breast cancer and diagnosis of one unknown type of cancer).

In response to this request, CAP staff reviewed the most recent data available from the Massachusetts Cancer Registry (MCR) and the Registry of Vital Records and Statistics to confirm cancer diagnoses reported among staff at the Joshua Eaton School and to determine whether these diagnoses may represent an unusual pattern of cancer incidence. The MCR, a division within the Massachusetts Department of Public Health (MDPH) Center for Health Information, Statistics, Research and Evaluation, is a population based surveillance system that has been monitoring cancer incidence in the Commonwealth since 1982. All new diagnoses of cancer among Massachusetts residents are required by law to be reported to the MCR within six months of the date of diagnosis (M.G.L. c.111. s 111b). This information is kept in a confidential database. Data are collected on a daily basis and are reviewed for accuracy and completeness on an annual basis. This process corrects misclassification of data (i.e., city/town misassignment) and deletes duplicate case reports. Once these steps are finished, the data for that year are considered "complete." Due to the volume of information received by the MCR, the large number of reporting facilities, and the six-month period between diagnosis and required reporting, the most current registry data that are complete will inherently be a minimum of two years prior to the current date. Although the MCR data are currently complete through 2000, this is an on-going surveillance system that collects reports on a daily basis. Therefore, it is possible to review case reports for more recent years (i.e., 2001 - present).

As stated above, six employees of the Joshua Eaton School were reported as having been diagnosed with cancer since 2001. For each of the employees reported, name, gender, cancer type, and length of employment at the Joshua Eaton School were provided to the CEH. An approximate age and date of diagnosis was reported for the majority of these individuals. Five of the six individuals were reported as having been diagnosed with breast cancer. Staff at the Joshua Eaton School were unsure of the specific cancer type diagnosed in the sixth individual. However, school employees reported that this staff member was not diagnosed with the same cancer type as the other five individuals. In addition, a seventh staff member of the Joshua Eaton School reported to the CEH had been diagnosed with a pre-cancerous breast disease. Specific diagnosis information for this individual (i.e., age and date of diagnosis) and approximate length of employment at the school was also provided to the CEH.

Based on information available through the MCR, CAP staff were able to confirm the diagnoses of four of the seven individuals reported to the CEH. Diagnoses of breast cancer (both invasive and non-invasive) were confirmed among these four individuals. All four individuals were diagnosed during the time period 2001 – 2003. Through a search of Massachusetts death records available from the Registry of Vital Records and Statistics, another division within the MDPH Center for Health Information, Statistics, Research and Evaluation, CAP staff were able to confirm the cause of death for a fifth staff member of the Joshua Eaton school who had been reported to the CEH with a diagnosis of cancer (unknown) but was not listed in the MCR. The cancer type listed on this individual's death certificate was not breast cancer which is consistent with information supplied to the CEH by school staff.

CAP staff were not able to confirm the diagnoses of all individuals with cancer that were reported to the CEH. There are several reasons for this described below. The MCR data is currently complete and final through 2000; however, this is an on-going surveillance system that collects reports on a daily basis. Although we reviewed the MCR data for cancer diagnoses through the present time, it is possible that some residents of Massachusetts diagnosed with cancer may not yet be included in the MCR files. For example, some individuals with recent cancer diagnoses (e.g., those diagnosed in 2003 and 2004) may not have been reported to the MCR yet. Finally, some individuals may have been diagnosed with non-invasive cancer types (i.e., benign tumors) or other pre-cancerous or non-cancerous conditions. These individuals would not be included in the MCR data files.

It is important to mention that breast cancer is the most common type of cancer diagnosed among females in Massachusetts and the United States. A female's risk for developing this cancer can change over time due to many factors, some of which are dependent upon the well-established risk factors for this cancer type. In Massachusetts, incidence rates increase noticeably in the 45 to 64 year age group. All four staff members confirmed in the MCR with breast cancer were in this age range at the time of diagnosis. For the other two staff members reported to the CEH but not identified in the MCR (one with a diagnosis of breast cancer and the other with a pre-cancerous breast disease), an age at diagnosis was provided. Each individual reported that their diagnoses occurred after the age of 45.

It is very important to consider the latency period of a disease when trying to determine if a particular environmental exposure could have contributed to that disease outcome. Cancer in general has a long period of development or latency period (i.e., the interval between first exposure to a disease-causing agent and the appearance of symptoms of the disease [Last 1995]) that can range from 10 to 30 years and in some cases may be more than 40 to 50 years for solid tumors (Bang 1996; Frumkin 1995). Although it is not possible to determine what may have caused any one person's diagnosis with cancer, the length of time in which an individual worked in a particular building can help determine the importance that their location might have in terms of exposure to a potential environmental source. The latency period for breast cancer, which refers to the time between exposure to a causative factor and development of the disease, is believed to be between 8 and 15 years (Lewis-Michl et al. 1996; Aschengrau, Paulu and Ozonoff 1998; Petralia et al. 1999).

Two of the four staff members with a confirmed diagnosis of breast cancer in the MCR reportedly worked at the Joshua Eaton School between 10 and 25 years prior to their diagnoses. Information reported on the other two staff members confirmed in the MCR indicated that they each worked at the school less than eight years prior to their diagnoses. Based on the date of diagnosis and length of employment reported to the CEH for the two staff members who could not be identified in the MCR, one individual (reported with breast cancer) worked at the school between 15 and 20 years prior to diagnosis, while the second individual (reported with pre-cancerous breast disease) worked at the school less than eight years prior to diagnosis.

Females with a family history of breast cancer are at an increased risk of developing the disease. Although the MCR database does not contain information about an individual's family history of cancer, some staff at the Joshua Eaton School provided the CEH with information related to their family history of cancer during the building inspection. None of the four employees who were confirmed in the MCR with breast cancer reported having a relative who had also been diagnosed with this cancer type. Two employees of the Joshua Eaton School reported to the CEH but not confirmed in the MCR (one with a diagnosis of breast cancer and one with pre-cancerous breast disease) both reported having a first-degree relative (i.e., mother, sister) with breast cancer, which may have played a role in their diagnoses.

Females at an increased risk for this cancer type include those individuals who have not had children or who had their first child after the age of 30. Females who take menopausal hormone therapy (either estrogen alone or estrogen plus progestin) for five or more years after menopause also appear to have an increased risk of developing breast cancer (National Cancer Institute 2003). Despite the vast number of studies on the causation of breast cancer, known factors are estimated to account for fewer than half of all diagnoses of this type of cancer in the general population (Madigan et al. 1995). Researchers are continuing to examine potential risks for breast cancer, including environmental factors.

As stated earlier, information on the type of cancer diagnosed in one former staff member was confirmed through the individual's death record. While CEH were able to obtain information on this individual's cancer diagnosis (i.e., uterine cancer) from the death certificate, age at diagnosis and date of diagnosis are not available on the certificate. Because a date of diagnosis could not be determined for this individual, it is unknown how long this staff member worked at the Joshua Eaton School prior to being diagnosed with cancer. However, while some risk factors for this cancer type are related to those associated with breast cancer (i.e., being female, age, use of hormone replacement therapy), exposures to environmental and/or occupational factors are not thought to be related to this type of cancer (ACS 2004).

It is important to keep in mind that cancer is a common disease. The American Cancer Society estimates that one out of every three Americans will develop some type of cancer during his or her lifetime. Over the past forty years, the rise in the number of cancer cases generally reflects the increase in the population, particularly in the older age groups. However, although most cancer types occur more frequently in older populations (i.e., age 50 and over), cancer can affect people of all ages. The most commonly diagnosed cancers for adult males include cancers of the prostate, lung and bronchus, and colon. Breast, lung and bronchus, and colon cancers are the most common cancer types diagnosed among females (ACS 2002).

Understanding that cancer is not one disease, but a group of diseases is also very important. Research has shown that there are more than 100 different types of cancer, each with different causative (or risk) factors. In addition, cancers of a certain tissue type in one organ may have a number of causes. Cancer may also be caused by one or several factors acting over time. For example, tobacco use has been linked to lung, bladder, and pancreatic cancers. Other factors related to cancer may include lack of crude fiber in the diet, high fat consumption, alcohol abuse, and reproductive history. Heredity, or family history, is an important risk factor for several cancers. To a lesser extent, some occupational exposures, such as jobs involving contact with asbestos, have been shown to be carcinogenic (cancer causing). Environmental contaminants have also been associated with certain types of cancer (Bang 1996; Frumkin 1995).

According to American Cancer Society statistics, cancer is the second leading cause of death in Massachusetts and the United States. Not only will one out of three people develop cancer in their lifetime, but this tragedy will affect three out of every four families. For this reason, cancers often appear to occur in "clusters," and it is understandable that someone may perceive that there are an unusually high number of cancer cases in their surrounding neighborhoods or towns. Upon close examination, many of these "clusters" are not unusual increases, as first thought, but are related to such factors as local population density, variations in reporting or chance fluctuations in occurrence. In other instances, the "cluster" in question includes a high concentration of individuals who possess related behaviors or risk factors for cancer. Some, however, are unusual; that is, they represent a true excess of cancer in a workplace, a community, or among a subgroup of people. A suspected cluster is more likely to be a true cancer cluster if it involves a large number of cases of one type of cancer diagnosed in a relatively short time period rather than several different types diagnosed over a long period of time (i.e., 20 years), a rare type of cancer rather than common types, and/or a large number of cases diagnosed among individuals in age groups not usually affected by that cancer. These types of clusters may warrant further public health investigation.

Based upon our review of the available diagnosis information, as well as the most current cancer literature, there does not appear to be an atypical pattern of cancer diagnoses among staff at the Joshua Eaton School. Age at diagnosis among employees diagnosed with breast cancer was not different from the age pattern established for this cancer type and information reported to the CEH indicated that family history of breast cancer probably played a role in the diagnosis of two individuals. Also, length of employment in the building prior to diagnosis for two other staff members diagnosed with breast cancer was not consistent with the latency period reported in the literature for this cancer type. Additionally, while potential indoor air quality problems were noted in this report, these issues are not likely to be related to the incidence of cancer among employees at the school. For more information regarding risk factors for breast cancer, the most common type of cancer reported among employees at the school, please refer to Appendix C.

Conclusions/Recommendations

The conditions noted at the JEES raise a number of indoor air quality issues. In addition to the IAQ assessment, BEHA staff also evaluated information in an attempt to identify possible environmental sources that have been suggested to play a role in the cancer development. No evidence of direct sources associated with the disease were identified in the building. A number of minor issues regarding general building conditions, design and routine maintenance that can affect indoor air quality were observed. These factors can be associated with a range of IAQ related health and comfort complaints (e.g., eye, nose, and respiratory irritations), but they are unlikely to be associated with cancer occurrences among employees. In view of the findings at the time of the visit, the following recommendations are made:

1. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room.
2. Continue working with HVAC engineering firm to resolve heating issues involving the freezing of univent coils. Consider consulting an HVAC engineer concerning the calibration of univent fresh air control dampers.

3. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
4. Consider adopting a balancing schedule of every 5 years for mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
5. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).
6. Ensure all roof leaks are repaired, and replace water damaged ceiling tiles. Examine the area above and around water-damaged areas for mold growth. Disinfect areas with an appropriate antimicrobial.
7. Make repairs to the drainage system to direct rain water away from the building.
8. Repair/replace damaged/failing window gaskets to prevent water penetration and drafts.
9. Repair faucet/sink leaks in classrooms 13 and 17.
10. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard. Inspect wallboard for water damage and mold/mildew growth, repair/ replace as necessary. Disinfect areas with an appropriate antimicrobial, as needed.
11. Remove plants from the vicinity of univents. Ensure plants are equipped with drip pans. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
12. Clean chalkboards and dry erase board trays regularly to avoid the build-up of particulates.

13. Clean/change filters for portable air purifiers and unit ventilators as per manufacturer's instructions or more frequently if needed.

14. Clean interiors of univents during each filter change.

15. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

16. Clean exhaust/return vents periodically to prevent excessive dust build-up.

17. Consider discontinuing the use of tennis balls on chairs to prevent latex dust generation.

18. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled in case of emergency.

19. Consider adopting the US EPA (2000b) document, Tools for Schools, in order to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

20. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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Picture 1

Typical Classroom Univent

Picture 2

Univent Air Intakes Sealed With Plastic

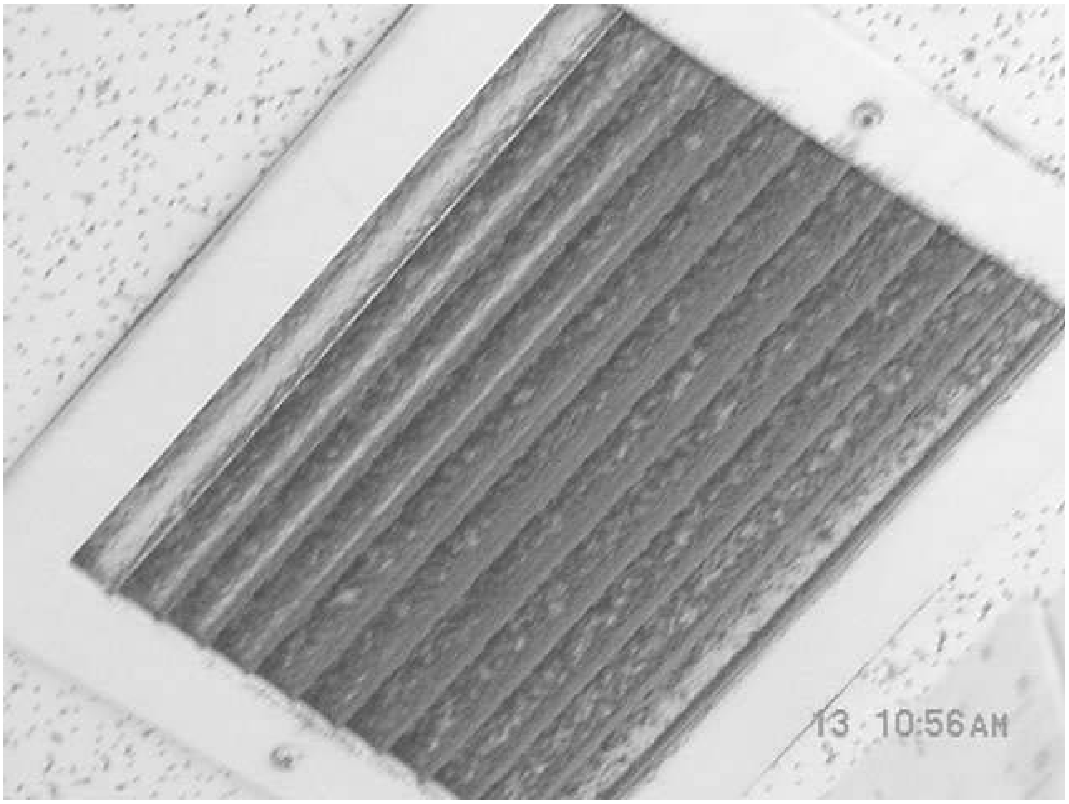
Picture 3

Univent Obstructed By Materials on and in Front of Unit

Picture 4

Exhaust "Cubby" in 1948 Portion of the Building Used as Storage

Picture 5



Ceiling-Mounted Return Vent, Note Dirt/Dust Accumulation

Picture 6

Wall-Mounted Exhaust Vent

Picture 7

Plant Debris on Flat Surfaces

Picture 8

Water Damaged Ceiling Tiles

Picture 9

Breaches between the Sink Countertop and Backsplash

Picture 10

Failing Rubber Gaskets around Window Panes in Classroom 16

Picture 11

Cleaning Chemicals in Classroom on Sink Countertop

Picture 12

Tennis Balls on the Bottom of Chair Legs

Picture 13

Air Purifier in Classroom

Joshua Eaton Elementary School,
365 Summer Ave., Reading MA 01867

Indoor Air Results
April 13, 2004

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (outdoors)	89	43	375	ND	ND	8			-	-	Atmospheric conditions: NE wind, 10-15 mph, moderate to heavy rain
Gym instructor office	70	39	648	ND	ND	10	0		Y	Y	Ceiling supply, ceiling exhaust
Gym	69	39	584	ND	ND	10	88		Y	Y	Ceiling supply, wall exhaust
18	70	40	853	ND	ND	13	27	Y	Y	Y	Tennis balls, cleaners; Univent supply,
20	72	32	634	ND	ND	6	1	Y	Y	Y	Breach sink/counter, dry erase materials, hallway door open; 22 occupants gone ~ 5 min. Ripped window screen; Univent supply, wall exhaust blocked by furniture
19	73	34	1018	ND	ND	13	23	Y	Y	Y	Breach sink/counter, tennis balls, cleaners, Univent supply blocked by furniture, wall

ppm = parts per million parts of air
µg/m3 = microgram per cubic meter
WD = water damage
AD = air deodorizer
AP = air purifier

CD = chalk dust
DEM = dry erase marker
DO = door open
ND = non detect
PC = photocopier

PF = personal fan
TB = tennis balls
UF = upholstered furniture
UV = univent
CT = ceiling tile
MT/AT = missing/ajar tile

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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Indoor Air Results

April 13, 2004

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Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
											exhaust blocked by furniture
Teachers' Workroom	71	32	415	ND	ND	2	0	Y	Y	Y	Photocopier, laminator, univent supply blocked by furniture; ceiling exhaust
Nurse	72	32	510	ND	ND	4	0	Y	Y	Y	5 Water damaged ceiling tile, hallway door open, ceiling supply, ceiling exhaust
24	74	34	696	ND	ND	6	22	Y	Y	Y	Dry erase materials, tennis balls, Univent supply, wall exhaust
23	74	34	845	ND	ND	7	23	Y	Y	Y	4 water damaged ceiling tile, dry erase materials, tennis balls. Univent supply, wall exhaust
1	72	33	654	ND	ND	8	22	Y	Y	Y	Dry erase materials, tennis balls, plants, hallway door open; univent supply blocked by furniture and clutter

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2	72	34	701	ND	ND	12	0	Y	Y	Y	Cleaners, occupants gone to lunch, Univent supply blocked by furniture, wall exhaust
3	72	34	789	ND	ND	12	23	Y	Y	Y	Dry erase materials, tennis balls, plants, hallway door open, Univent supply, Exhaust blocked by clutter.
4	69	33	643	ND	ND	5	24	Y	Y	Y	Water damaged ceiling, dry erase markers, tennis balls, cleaners, plants; Univent supply, wall exhaust blocked by clutter.
5	73	32	660	ND	ND	10	23	Y	Y	Y	Tennis balls, hallway door open, Univent supply blocked by furniture, wall exhaust blocked by clutter
6	75	33	612	ND	ND		2		Y	Y	Water damaged ceiling, dry erase materials, tennis balls, 22 Occupants gone 25 min.; Univent supply, wall exhaust blocked by furniture.

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									Supply	Exhaust	
Staff lounge	73	33	608	ND	ND	5	8	Y	Y	Y	Ceiling supply, ceiling exhaust occluded by dirt/debris
7 Reading Room	73	33	626	ND	ND	7	7	Y	Y	Y	1 water damaged ceiling tile, hallway door open, Univent supply, ceiling exhaust
8	73	35	1220	ND	ND	9	23	Y	Y	Y	Air purifier, dry erase materials, tennis balls, red light "on' pre filter (HEPA air purifier),Univent supply blocked by clutter, wall exhaust
9	73	34	790	ND	ND	12	21	Y	Y	Y	7 water damaged ceiling tile, chalk dust, dry erase materials, Univent supply blocked by clutter, wall exhaust
Art Room	71	34	785	ND	ND	15	1	Y		Y	8 Water damaged ceiling tile, hallway door open, ceiling exhaust occluded by dirt/debris
Cafetorium	73	38	785	ND	ND	29	~100	Y	Y	Y	2 Water damaged ceiling tile, hallway door open, wall supply, wall exhaust.

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10	73	34	880	ND	ND	9	20	Y	Y	Y	Tennis balls, cleaners, Univent supply blocked by clutter and furniture, wall exhaust
11	73	34	699	ND	ND	9	1	Y	Y	Y	Plants, ~25 occupants gone 25 min. Univent supply, wall exhaust
12	72	34	505	ND	ND	5	0	Y	Y	Y	Dry erase materials, tennis balls, hallway door open, Univent supply, weak exhaust
13	70	34	700	ND	ND	7	0	Y	Y	Y	Dry erase materials, tennis balls, hallway door open, faucet leak on countertop, rubber stripping, Occupants gone to lunch 5 min. Univent supply, wall exhaust
14	73	32	672	ND	ND	7	0	Y	Y	Y	Tennis balls, cleaners, hallway door open, ammonia, Univent supply
15	75	35	683	ND	ND	6	21	Y	Y	Y	Tennis balls, cleaners, Univent supply, wall exhaust blocked by clutter

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16	73	33	796	ND	ND	10	1	Y	Y	Y	Tennis balls, cleaners, ~18 OCL done 5 min., rubber seals windows loose, Univent supply, wall exhaust
17	75	40	960	ND	ND	12	22	Y	Y	Y	Dry erase materials, tennis balls, plants, hallway door open, sink leak WD wood, feather duster, Univent supply, wall exhaust
Speech & Language	72	31	418	ND	ND	2	0	Y	Y	Y	2 Water damaged ceiling tile, hallway door open, ceiling supply, wall exhaust blocked by boxes and clutter.
21	72	32	475	ND	ND	4	1	Y	Y	Y	Dry erase materials, tennis balls, Univent supply blocked by clutter, wall exhaust
22	74	31	534	ND	ND	2	5	Y	Y	Y	Water damaged ceiling, tennis balls, cleaners, plants; Univent supply blocked by furniture and plants, wall exhaust blocked by clutter.

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Media Center	78	30	493	ND	ND	3	3	Y	Y	Y	3 Water damaged ceiling tile, hallway door open; Univent supply blocked by clutter, ceiling exhaust
Outside Perimeter of Building											2 UV air intakes blocked with plastic, gutter/downspout – disconnected (several). Water pooling against building.
Main office	72	36	515	ND	ND	4	3	Y	Y	Y	2 water damaged ceiling tile, hallway door open, ceiling supply, ceiling exhaust
Principal's Office	78	43	464	ND	ND	3	2	Y	Y	Y	Bubbler over carpet, hallway door open, noisy vent system, ceiling supply, ceiling exhaust

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Appendix C

RISK FACTOR INFORMATION FOR SELECTED CANCER TYPES

Breast Cancer

Breast cancer is the most frequently diagnosed cancer among women in both the United States and in Massachusetts. According to the North American Association of Central Cancer Registries, female breast cancer incidence in Massachusetts is the fifth highest among all states (Chen et al, 2000). Although during the 1980s breast cancer in the U.S. increased by about 4% per year, the incidence has leveled off to about 110.6 cases per 100,000 (ACS 2000). A similar trend occurred in Massachusetts and there was even a slight decrease in incidence (1%) between 1993 and 1997 (MCR 2000).

In the year 2004, approximately 216,000 women in the U.S. will be diagnosed with breast cancer (ACS 2004). Worldwide, female breast cancer incidence has increased, mainly among women in older age groups whose proportion of the population continues to increase as well (van Dijck, 1997). A woman's risk for developing breast cancer can change over time due to many factors, some of which are dependent upon the well-established risk factors for breast cancer. These include increased age, an early age at menarche (menstruation) and/or late age at menopause, late age at first full-term pregnancy, family history of breast cancer, and high levels of estrogen. Other risk factors that may contribute to a woman's risk include benign breast disease and lifestyle factors such as diet, body weight, lack of physical activity, consumption of alcohol, and exposure to cigarette smoke. Data on whether one's risk may be affected by exposure to environmental chemicals or radiation remains inconclusive. However, studies are continuing to investigate these factors and their relationship to breast cancer.

Family history of breast cancer does affect one's risk for developing the disease. Epidemiological studies have found that females who have a first-degree relative with premenopausal breast cancer experience a 3-fold greater risk. However, no increase in risk has been found for females with a first degree relative with postmenopausal breast cancer. If women have a first-degree relative with bilateral breast cancer (cancer in both breasts) at any age then their risk increases five-fold. Moreover, if a woman has a mother, sister or daughter with bilateral premenopausal breast cancer, their risk increases nine fold. (Broeders and Verbeek, 1997). In addition, twins have a higher risk of breast cancer compared to non-twins (Weiss et al, 1997).

A personal history of benign breast disease is also associated with development of invasive breast cancer. Chronic cystic or fibrocystic disease is the most commonly diagnosed benign breast disease. Women with cystic breast disease experience a 2-3 fold increase in risk for breast cancer (Henderson et al, 1996).

According to recent studies, approximately 10% of breast cancers can be attributed to inherited mutations in breast cancer related genes. Most of these mutations occur in the BRCA1 and BRCA2 genes. Approximately 50% to 60% of women who inherit BRCA1 or BRCA2 gene mutations will develop breast cancer by the age of 70 (ACS 2001).

Cumulative exposure of the breast tissue to estrogen and progesterone hormones may be one of the greatest contributors to risk for breast cancer (Henderson et al, 1996). Researchers suspect that early exposures to a high level of estrogen, even during fetal development, may add to one's risk of developing breast cancer later in life. Other studies have found that factors associated with increased levels of estrogen (i.e., neonatal jaundice, severe prematurity, and being a fraternal twin) may contribute to an elevated risk of developing breast cancer (Ekbom et al, 1997). Conversely, studies have revealed that women whose mothers experienced toxemia during pregnancy (a condition associated with low levels of estrogen) had a significantly reduced risk of developing breast cancer. Use of estrogen replacement therapy is another factor associated with increased hormone levels and it has been found to confer a modest (less than two-fold) elevation in risk when used for 10-15 years or longer (Kelsey, 1993). Similarly, more recent use of oral contraceptives or use for 12 years or longer seems to confer a modest increase in risk for bilateral breast cancer in premenopausal women (Ursin et al, 1998).

Cumulative lifetime exposure to estrogen may also be increased by certain reproductive events during one's life. Women who experience menarche at an early age (before age 12) have a 20% increase in risk compared to women who experience menarche at 14 years of age or older (Broeders and Verbeek, 1997; Harris et al, 1992). Women who experience menopause at a later age (after the age of 50) have a slightly elevated risk for developing the disease (ACS 2001). Furthermore, the increased cumulative exposure from the combined effect of early menarche and late menopause has been associated with elevated risk (Lipworth, 1995). In fact, women who have been actively menstruating for 40 or more years are thought to have twice the risk of developing breast cancer than women with 30 years or less of menstrual activity (Henderson et al, 1996). Other reproductive events have also shown a linear association with risk for breast cancer (Wohlfahrt, 2001). Specifically, women who gave birth for the first time before age 18 experience one-third the risk of women who have carried their first full-term pregnancy after age 30 (Boyle et al, 1988). The protective effect of earlier first full-term pregnancy appears to result from the reduced effect of circulating hormones on breast tissue after pregnancy (Kelsey, 1993).

Diet, and particularly fat intake, is another factor suggested to increase a woman's risk for breast cancer. Currently, a hypothesis exists that the type of fat in a woman's diet may be more important than her total fat intake (ACS 1998; Wynder et al, 1997). Monounsaturated fats (olive oil and canola oil) are associated with lower risk while polyunsaturated (corn oil, tub margarine) and saturated fats (from animal sources) are linked to an elevated risk. However, when factoring in a woman's weight with her dietary intake, the effect on risk becomes less clear (ACS 1998). Many studies indicate that a heavy body weight elevates the risk for breast cancer in postmenopausal women (Kelsey, 1993), probably due to fat tissue as the principal source of estrogen after menopause (McTiernan, 1997). Therefore, regular physical activity and a reduced body weight may decrease one's exposure to the hormones believed to play an important role in increasing breast cancer risk (Thune et al, 1997).

Aside from diet, regular alcohol consumption has also been associated with increased risk for breast cancer (Swanson et al, 1996; ACS 2001). Women who consumed one alcoholic beverage per day experienced a slight increase in risk (approximately 10%) compared to non-drinkers, however those who consumed 2 to 5 drinks per day experienced a 1.5 times increased risk (Ellison et al., 2001; ACS 2001). Despite this association, the effects of alcohol on estrogen metabolism have not been fully investigated (Swanson et al, 1996).

To date, no specific environmental factor, other than ionizing radiation, has been identified as a cause of breast cancer. The role of cigarette smoking in the development of breast cancer is unclear. Some studies suggest a relationship between passive smoking and increased risk for breast cancer; however, confirming this relationship has been difficult due to the lack of consistent results from studies investigating first-hand smoke exposure (Laden and Hunter, 1998).

Studies on exposure to high doses of ionizing radiation demonstrate a strong association with breast cancer risk. These studies have been conducted in atomic bomb survivors from Japan as well as patients that have been subjected to radiotherapy in treatments for other conditions (i.e., Hodgkin's Disease, non-Hodgkin's Lymphoma, tuberculosis, post-partum mastitis, and cervical cancer) (ACS 2001). However, it has not been shown that radiation exposures experienced by the general public or people living in areas of high radiation levels, from industrial accidents or nuclear activities, are related to an increase in breast cancer risk (Laden and Hunter, 1998). Investigations of electromagnetic field exposures in relation to breast cancer have been inconclusive as well.

Occupational exposures associated with increased risk for breast cancer have not been clearly identified. Experimental data suggests that exposure to certain organic solvents and other chemicals (e.g., benzene, trichloropropane, vinyl chloride, polycyclic aromatic hydrocarbons (PAHs)) causes the formation of breast tumors in animals and thus may contribute to such tumors in humans (Goldberg and Labreche, 1996). Particularly, a significantly elevated risk for breast cancer was found for young women employed in solvent-using industries (Hansen, 1999). Although risk for premenopausal breast cancer may be elevated in studies on the occupational exposure to a combination of chemicals, including benzene and PAHs, other studies on cigarette smoke (a source of both chemicals) and breast cancer have not shown an associated risk (Petralia et al, 1999). Hence, although study findings have yielded conflicting results, evidence does exist to warrant further investigation into the associations.

Other occupational and environmental exposures have been suggested to confer an increased risk for breast cancer in women, such as exposure to polychlorinated biphenyls (PCBs), chlorinated hydrocarbon pesticides (DDT and DDE), and other endocrine-disrupting chemicals. Because these compounds affect the body's estrogen production and metabolism, they can contribute to the development and growth of breast tumors (Davis et al, 1997; Holford et al, 2000; Laden and Hunter, 1998). However, studies on this association have yielded inconsistent results and follow-up studies are ongoing to further investigate any causal relationship (Safe, 2000).

When considering a possible relationship between any exposure and the development of cancer, it is important to consider the latency period. Latency refers to the time between exposure to a causative factor and the development of the disease outcome, in this case breast cancer. It has been reported that there is an 8 to 15 year latency period for breast cancer (Petralia 1999; Aschengrau 1998; Lewis-Michl 1996). That means that if an environmental exposure were related to breast cancer, it may take 8 to 15 years after exposure to a causative factor for breast cancer to develop.

Socioeconomic differences in breast cancer incidence may be a result of current screening participation rates. Currently, women of higher socioeconomic status (SES) have higher screening rates, which may result in more of the cases being detected in these women. However, women of higher SES may also have an increased risk for developing the disease due to different reproductive patterns (i.e., parity, age at first full-term birth, and age at menarche). Although women of lower SES show lower incidence rates of breast cancer in number, their cancers tend to be diagnosed at a later stage (Segnan, 1997). Hence, rates for their cancers may appear lower due to the lack of screening participation rather than a decreased risk for the disease. Moreover, it is likely that SES is not in itself the associated risk factor for breast cancer. Rather, SES probably represents different patterns of reproductive choices, occupational backgrounds, environmental exposures, and lifestyle factors (i.e., diet, physical activity, cultural practices) (Henderson et al, 1996).

Despite the vast number of studies on the causation of breast cancer, known factors are estimated to account for less than half of breast cancers in the general population (Madigan et al, 1995). Researchers are continuing to examine potential risks for developing breast cancer, especially environmental factors.

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